A Review of the Present Knowledge of Mine Burial Processes

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LONG-TERM GOAL

The ultimate long-term goal of the ONR Mine Burial Prediction (MBP) Research Program is the development of mine burial probability models that incorporate dynamic coupled processes, seafloor material properties, and different mine types.

SCIENTIFIC OBJECTIVES

The immediate scientific objectives of this particular component of the MBP program is to aid in the production of a report that incorporates the present knowledge of mine burial processes and state-of-the-art mine burial modeling in the areas of present critical navy interest.

APPROACH

In this component project I have been working closely with Mike Richardson, Head of the Seafloor Sciences Branch of the Marine Geosciences Division of the Naval Research Laboratory. My portion of the report revision effort is a relatively small project, involving only 80 hours of personnel time from my institution. Together with Mike Richardson and Phil Valent at NRL, I have been helping to revise an existing draft report, entitled "Modeling of Mine Burial Processes: A Review", that was initiated by Daniel Lott, also of NRL. My focus has been on sections of the report involving modeling of mine burial by scour and by bedform migration.

WORK COMPLETED

I have delivered to NRL revised sections of the mine burial report focusing on the WISSP, NBURY, DRAMBUIE and Vortex Lattice models for scour burial and the Mulhearn model for bedform burial. These contributions are now incorporated into a revised report (Lott, 2001) by NRL personnel.

RESULTS

WISSP was originally written in the 1960's and is presently maintained by the U.S. Naval Coastal Systems Center. Availability of the source code allowed identification of the assumptions of this model. This model solves empirical relations for initiation of bedload and suspended load transport of sand to determine whether scour burial is likely. If near bottom wave orbital velocities are not large enough to initiate bed load, burial is assumed not to occur. If waves are sufficient to initiate bed load but not suspended load, partial burial is predicted. If waves are large enough to initiate suspended load, total burial is predicted.

Report Documentation Page

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14. ABSTRACT
The ultimate long-term goal of the ONR Mine Burial Prediction (MBP) Research Program is the development of mine burial probability models that incorporate dynamic coupled processes, seafloor material properties, and different mine types.

15. SUBJECT TERMS

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NBURY is a scour model developed by Industrie Anlagen Bau Gesellschaft of Munich, Germany, for the German Navy (Stender, 1980). This model for wave-induced scour is based on the Carstens and Marten (1963) equations documenting the response of mine-like objects to wave-induced scour as observed in a laboratory wave tank. Availability of the Carstens and Marten report allowed confirmation of the NBURY implementation of the Carstens and Marten equations. Carstens and Marten (1963) derived separate empirical relations for the rate of wave-induced scour around mines due to bedload and suspended load.

DRAMBUIE is preliminary version of a current-induced scour model being developed by the United Kingdom (HR Wallingford Ltd, 1994). This model is based on empirical solutions for current-induced scour around pilings using standard formulations available in recently published textbooks by Soulsby (1997) and by Whitehouse (1998). Empirical coefficients in formulae derived for pilings have been modified to match results for current-induced scour observed around mine-like objects in laboratory flumes. The recent engineering literature allowed successful evaluation of this model's formulation.

The Vortex-Lattice model is a R&D model, developed by Jenkins and Inman at Scripps. There are two basic mechanisms in the present Vortex-Lattice formulation of mine scour and burial (Inman and Jenkins, 1999): (1) a near-field burial mechanism involving sediment transport by the vortices shed from the mine shape; and (2) a far-field burial and exposure mechanism that involves changes in the elevation of the seabed due to accretion or erosion of the entire nearshore profile. The near-field component of the model has an excellent physics-based foundation. However, in its present form it is strictly a developmental model that is geared toward science-based objectives.

The Mulhearn model for bedform migration was sponsored by the Australian Defence Science Technology Organisation and calculates time for burial of mines by large migrating bedforms. This model combines a bedload transport formulation based on mean current velocity (van den Berg, 1987) with a continuity relation for sediment transport based on bedform migration. This model is well documented by the available Mulhearn (1996) report. Although the Kalinske-Frijlink equation for bedload transport used in this model is not a widely accepted formulation, the Mulhearn approach is very simple, and it would be easy to substitute an alternative formula for bedload transport if necessary.

IMPACT/APPLICATIONS

The revised report entitled "Modeling of Mine Burial Processes: A Review" will help the operational Navy to make informed choices concerning the use of existing mine burial models. A documented knowledge of existing models will also aid the Navy in identifying what areas of mine burial prediction are most in need of more advanced formulations.

TRANSITIONS

My revisions have been delivered to Dr. Mike Richardson, Head of the Seafloor Sciences Branch of the Marine Geosciences Division of the Naval Research Laboratory. NRL is leading the final revision of the report and its delivery to the operational Navy.

RELATED PROJECTS

This project is part of the ongoing ONR Marine Geosciences Program in Mine Burial Prediction Research. Several additional projects in the MBP progam are listed under Marine Geosciences in the directory containing this report.

The following projects involving Friedrichs outside of the MBP Research Program also address sediment transport in coastal environments:

1. Sediment Dynamics of a Microtidal Partially-Mixed Estuary. National Science Foundation (Marine Geology and Geophysics).

2. Integration of an Analytical Model for Shelf Sediment Deposition into SedFlux. Office of Naval Research (Marine Geosciences).

3. How Do Estuarine Turbidity Maxima Entrap Particles, Retain Zooplankton, and Promote Recruitment of Fish? National Science Foundation (Biological Oceanography).

REFERENCES

HR Wallingford Ltd. 1994: Summary of Procedures for the Prediction of Burial of Isolated Objects. Report No. EX3023.

Inman, D.L. and Jenkins, S.A. 1999: Scour Mechanics of Aggregate Obstacle Fields with Application to Mine Countermeasures. ONR Annual Report, Contract No. N00014-95-1-0005.

Lott, D.F. 2001: Modeling Mine Burial Processes: A Review. With contributions by C. Friedrichs, M. Richardson, and P. Valent. Naval Research Laboratory, Stennis Space Center, MS, in preparation.

Mulhearn, P.J. 1996: A Mathematical Model for Mine Burial by Mobile Underwater Sand Dunes. Aeronautical and Maritime Research Laboratory, Defence Science and Technology Organisation, Melbourne, Australia. DSTO-TR-0290 AR No. AR-009-465.

Soulsby, R. 1997: Dynamics of Marine Sands: A Manual for Practical Applications. Thomas Telford Publications, London.

Stender, I. 1980: Die Versandung von Grundminen durch Seegang: Theoretische Grundlangen. FWG Rtp 1980-6. Forschungsanstalt der Bundeswehr für Wasserschall-und Geophysik, Kiel, Germany.

van den Berg, J.H. 1987: Bedform migration and bed-load transport in some rivers and tidal environments. Sedimentology, 34, 681-698.

Whitehouse, R.J.S. 1998: Scour at Marine Structures. Thomas Telford Publications, London.